B.C. Hydro

EFFECTS OF RIGHT-OF-WAY PRACTICES, ESTABLISHMENT, AND MAINTENANCE ON WILDLIFE

A. V. Miller

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Civil and Environmental Engineering Department
Operations Engineering Division

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Vegetation Management Supervisor
B. C. Hydro & Power Authority

Summary

The feasibility of creating wildlife habitat on transmission line rights-of-way is presented and discussed. Clearing methods for transmission line construction and vegetation maintenance procedures for established rights-of-way are described. Selective, site-specific use of herbicides is essential to manipulate right-of-way vegetation. The use of indigenous understory plant species, compatible with transmission lines, is the most economical method of vegetation management and promotes wildlife habitat.

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The advantages and disadvantages of multiple uses for transmission line rights-of-way (T/L R.O.W.) are well documented and are, therefore, not discussed in this paper. Usually such multiple (or alternate) uses such as cattle range, pasture, agricultural crops, Christmas tree farms, and recreation are emphasized. Wildlife uses are also acknowledged, but a concerted effort to accommodate wildlife specifically, is often not made. Frequently wildlife is relegated to share rights-of-way seeded to grass for range cattle and horses. Rangeland provides little winter forage for wildlife browsing.

Although the principles of managing vegetation on T/L R.O.W. to encourage wildlife apply to most animals, only the ungulates found in British Columbia are specifically addressed in this paper. Parallel conditions undoubtedly exist in other parts of Canada and the world.

Current vegetation management practices are described and general advantages and disadvantages are listed. The management prescription initiated prior to new line construction includes initial and subsequent clearing programs. Specific wildlife concerns are addressed as related to "state of the art" vegetation management.

Clearing of New T/L R.O.W.

Prior to initial clearing it is necessary to establish objectives for future vegetation management. Questions arise here whether cut logs and stumps should be removed or left on rights-of-way. These questions can only be answered by careful study of the terrain topography, soil types, climate, native vegetation, wildlife, and future uses of rights-of-way, such as agriculture, recreation, etc.

In initial clearing of the right-of-way four basic standards are used by B.C. Hydro:

- Standard A. The natural ground surface is disturbed as little as possible. Only handheld equipment is used. Stumps are not removed and debris over 15 cm diameter is left flat on the ground. Plant species, compatible with the transmission lines, are retained for ground cover. This clearing standard is used near streams and on wet, steep, or unstable terrain.

- Standard B. Similar to standard A, but all debris is removed by rubber-tired equipment or cable yarding machinery (with spar). This standard, in which stumps are not removed, is used on sensitive terrain where debris removal is required. Disturbance of soil and low growing vegetation is minimized as much as possible. Tracked equipment is not permitted.

- Standard C. In this standard tracked equipment is used to remove all trees, brush, and stumps up to 60 cm in diameter. Debris is removed and the disturbed terrain is groomed and seeded to grass. This clearing method is only used on stable ground and provides grazing for cattle.

- Standard D. Similar to standard C, but all stumps are removed. Disturbed terrain is groomed and seeded to grass for range and pasture, or cultivated for other agricultural uses.

Manual clearing methods include the use of all hand-operated tools and equipment, some of which are power equipped. Examples are handsaws, axes, machetes, sandviks, brushcutters, weedeaters, circular saws, and chainsaws.

Terrain accessibility and the proximity to water bodies or residential areas, where use of herbicides is strenuously opposed, may dictate their use.

In urban and some suburban areas, where power lines are in close proximity to ornamental trees, manual pruning and trimming is often the only feasible control method.

Advantages of manual control methods:

- Most conifers are effectively controlled when severed below the lowest branch as close to ground level as possible.
- Selective cutting and, hence, preservation of desirable plant species is possible.
- Aesthetics may be improved where dead leaves from herbicidal treatments are objectionable.
- Work progress and workmanship is clearly visible.
- Hand cutting may at times be the only alternative due to terrain conditions, proximity to water bodies, public opposition, or pesticide use permit conditions.

Disadvantages of manual control methods:

- The cut stumps (spears) may pose a serious safety hazard to the public, Hydro employees, and animals, especially when hidden by other vegetation.
- Hand cutting tools and equipment are dangerous to work with and cause worker injury.
- Manual controls are time consuming and expensive.
- Many deciduous tree species on the right-of-way are prone to regeneration of the stump and/or root, which usually results in regrowth of multiple stems, producing an aggravated future maintenance problem.
- Dried up slash on rights-of-way poses a fire hazard.

Machine clearing utilizes blade, bucket, and backhoe equipment, either on tracks or rubber tires, to prepare rights-of-way for vegetation management, specifically where grooming and seeding is required.

Advantages of machine clearing:

- Cleared rights-of-way are more uniform and provide accessible terrain for future vegetation management.
- Ranching and farming needs are served better when and where such needs are predetermined.

Disadvantages of machine clearing:

- Desirable understory plant species which are compatible to the powerlines are needlessly disturbed or destroyed.
- Prior to seeding and during establishment of a vigorous turf cover on rights-of-way, erosion may cause irreparable damage.
- Undesirable plant species will start to colonize cleared areas immediately.
- Wildlife is, at least initially, adversely affected.

Vegetation Management on Established T/L R.O.W.

Vegetation growth on T/L R.O.W. is controlled manually, mechanically, biologically, and chemically. In practice, combinations of control methods are the norm. The preferred control is biological.

- Manual controls have been discussed under clearing of new T/L R.O.W.

- Mechanical control to maintain T/L R.O.W. is usually done with mowers which vary in size and capability from grass mowers to brush cutters to hydro-axes, which will cut fir trees up to 35 cm in diameter. Such mowers may be self-propelled or attached to trucks or tractors.

The principal equipment used on powerline rights-of-way is the self-propelled hydro-axe on large rubber tires. Limitations are similar to manual controls, i.e. conifers must be cut under the lowest branch as close to the ground level as possible, while deciduous brush is prone to regeneration and is likely to pose an aggravated future maintenance problem.

Terrain topography, stumps, and rocks on rights-of-way place further limitations on the hydro-axe. Although the splintered cut ends of trees and brush pose a lesser hazard to man and animal than the "spears" left from manual cutting, they are still hazardous and disliked by cattle ranchers.

The claim that one hydro-axing will give control for five years should be discounted, as evidence suggests that the control cycle may last no more than two or three years, even in such British Columbia interior regions as the Kootenays.

In spite of all the aforementioned, the hydro-axe has a rightful place in vegetation management. In areas of appropriate terrain, where ground covers are interspersed with unwanted conifers and more mature deciduous trees such as red alder and birch, the hydro-axe has given lasting control with minimal disturbance of the ground covers. The hydro-axe is also very useful in interim vegetation control, followed by selective herbicidal treatment of the cut stumps, specifically where permitted spray heights are limited or massive "brown-outs" from herbicidal foliage sprays are objectionable.

Advantages of mechanical mowing (hydro-axe):

- Faster and usually more economical than manual controls.
- A useful tool for interim vegetation control.

- Less hazardous for operator than manually operated equipment.
- Aesthetics may be improved where dead leaves and bushes from herbicidal treatments are objectionable.
- Work progress and workmanship is clearly visible.
- Hydro-axing provides an alternative near water bodies and in watershed areas where current regulations may limit the use of herbicides.

Disadvantages of mechanical mowing (hydro-axe):

- Mowing is nonselective and cuts plant species which do not need control, thereby opening up niches for growth of undesirable plant species, while removing wildlife shelter and forage.
- In wet terrain, soil disturbance by tires may cause serious erosion problems.
- The tangled, splintered stumps are objectionable to man and animal.
- Many deciduous tree species on rights-of-way are prone to regeneration which results in an aggravated future maintenance problem.
- Terrain conditions severely restrict the effective use of the hydro-axe in many areas.

- Biological control of weeds, generally, has not been a great success story. Insects, fungi, and, to a lesser degree, plant eating mammals are the principal organisms usually considered as biological control agents of weeds.

    - Insects which feed only on a few selected plant species (host specific insects) will not eradicate these plant species completely as this would be paramount to self annihilation.
    - The use of insects which feed on many plant species (multiple host insects) to control vegetation on the right-of-way is not feasible as the insects would have to be programmed to stop eating when they reach agricultural, horticultural, and forestry crops.
    - Although research into fungi as weed controlling agents holds some promise for the future, at present the same limitations as those mentioned for insects apply.
    - Plant-eating mammals provide some measure of biological control. Moose browsing on willow have in some areas produced low dense growth, but cannot be considered as a widespread effective control. Grazing of cattle in pastures or on the range is an effective control and can reduce the fire hazard posed by high, dead grasses on rights-of-way in the spring.

However, desirable and undesirable plant species on rights-of-way represent a totally different challenge than the weeds normally encountered in cultural practices of agriculture, horticulture, and forestry.

Open spaces of land, created by whatever circumstances, are quickly colonized by pioneer species of plants. Eventually dominant species establish themselves as climax vegetation.

Climax tree species in the British Columbia Pacific Forest Regions and some Interior Districts are coniferous, while other regions have a mixture of coniferous and deciduous climax trees. All of these and a number of pioneer tree species are incompatible with powerlines on rights-of-way.

Smaller pioneer tree and brush species, many climax deciduous and broadleaved evergreen brush species, and ground covering plants in the understory are abundant in many parts of British Columbia. Many of these plant species will thrive in the absence of the climax forest canopy and are compatible with engineering needs for powerlines on rights-of-way. Native and cultured grasses together with many herbaceous plants may be used to further compliment this flora. As no two plants can fill the same niche, encouragement of desirable plant species discourages and often virtually eliminates the growth of undesirable plant species, minimizing future maintenance costs.

Biological control of undesirable plant species on T/L R.O.W. is achieved by manipulating the desirable plant species to form a relatively stable plant community. This plant association, a type of climax vegetation, may be comprised of native vegetation to support wildlife, grasses to support ranching and farming needs, farm crops, tree nurseries, Christmas tree farms, recreational areas, or any other multiple uses which meet specific needs.

The main thrust of vegetation management on rights-of-way should be carefully planned biological control.

Advantages of biological control:

- Manipulated desirable climax vegetation tends to suppress undesirable vegetation.
- Long-term vegetation management costs are reduced.
- Aesthetically it is more acceptable.
- Multiple uses of rights-of-way are served better.
- Fish and wildlife concerns are better addressed.
- Farming and ranching needs are taken into consideration.
- Public concerns are lessened.
- Erosion problems are decreased.

Disadvantages of biological control:

- Overemphasizing of grass seeding on rights-of-way may in some areas increase forest fire hazards.

Remembering the advantages and disadvantages of manual and mechanical controls, it should be clear that these tools of vegetation management are inadequate and will, when misused, compound rather than solve vegetation management problems.

- Chemical control, using herbicides, has been a very successful method of vegetation maintenance. Unfortunately, the problems associated with pesticides, especially insecticides, have been conveyed to herbicides.

Senior governments in Canada have passed legislation to regulate pesticide use and to safeguard man and his environment from unreasonable adverse effects:

- Federal legislation provides for the registration of pesticides and prescribes the evaluation of pesticide effectiveness and safe use.

- British Columbia provincial legislation further restricts the use of pesticides by setting competence levels to obtain commercial pesticide applicator certificates and by issuing permits for specific pesticide application programs.

The development of a repressive regulatory system has practically halted the development of new herbicides and reduced the number of existing alternative herbicides through use restrictions.

Herbicides are used to control unwanted vegetation. Some selective herbicides are intended for specific vegetation problems on rights-of-way, while special application techniques allow the selective use of nonselective herbicides. All herbicide uses on rights-of-way must be designed to eliminate the target plant species only, with minimal or no adverse effect on desirable vegetation.

Since 1978 the major herbicides that have been used on B. C. Hydro T/L R.O.W. are picloram and 2,4-D. The need for more suitable herbicides and more sophisticated application techniques is apparent.

In 1981 B. C. Hydro Vegetation Management has promoted and participated in research and field tests of specific herbicides and application techniques on T/L R.O.W. Such tests are conducted and evaluated jointly with chemical manufacturers and the B. C. Ministry of Agriculture under appropriate federal and provincial research permits. Results of several of these projects are very positive, evaluation of some cannot be completed until 1982. Testing of additional herbicides and techniques is planned for 1982. Concurrent with these programs the B. C. Hydro Research and Development Laboratory is exploring specific application techniques.

The intent of current and future testing is to provide Hydro field personnel with better and more selective vegetation management tools which will ensure the safety of the public, the hydro worker, the environment, while meeting engineering needs.

Initially the introduction of herbicides and application techniques, other than those for picloram and 2,4-D, will be slow. It is essential that field personnel and outside contractors have a working experience and confidence before herbicides and application techniques, heretofore unknown to them, are applied on a larger scale.

The objective of maximum biological control, coupled to minimal vegetation management costs, is in most instances not attainable without the safe and proper use of herbicides.

Advantages of chemical controls:

- Regeneration of unwanted vegetation can be controlled.
- Eventually biological control, with minimal vegetation management costs, can be attained.
- Multiple uses of rights-of-way are better served.

Disadvantages of chemical controls:

- Dead foliage caused by some herbicides is objectionable.
- Most herbicides cannot be used near water bodies.
- Greater skills and good judgement are required of the worker when using herbicides.
- Current chemical control methods used by hydro workers on rights-of-way are limited by the few herbicides available.
- The use of chemicals on the right-of-way as a maintenance tool, rather than a management tool, is, though legal, hard to defend.
- Public concerns.

Access to T/L R.O.W. must be considered and planned prior to initiating clearing of the rights-of-way. Traditionally roads have been constructed to and on the T/L R.O.W. to facilitate clearing, line construction, and future maintenance of transmission lines and vegetation. Terrain topography in some areas permits access by helicopter only. Prior to line construction helicopter "pads" are then often installed to provide permanent landing sites for future T/L R.O.W. management.

Easy access to right-of-way roads has led to abuses by unauthorized users and is often detrimental to the right-of-way environment.

Licence conditions for construction of new transmission lines now frequently call for removal of access roads and reseeding after completion of construction.

Wildlife Concerns Related to Vegetation Management on T/L R.O.W.

B. C. Hydro clearing standards A and B are best suited to enhance the right-of-way environment for wildlife habitat.

Many indigenous plant species in the understory are compatible with powerline requirements, will flourish when the overstory is removed, and may serve as (winter) forage for ungulates and other wildlife. Dan Blower (1982) has prepared a list entitled "Key Winter Forage Plants for B. C. Ungulates" - 3rd Draft. Table 1 reflects those indigenous species on the list which enhance wildlife habitat and biological control on the T/L R.O.W.

Standards C and D enhance grazing for cattle and promote agricultural uses. Wildlife shelter is virtually nonexistant, however, shelter and forage conditions for wildlife would improve if indigenous shrubby and groundcovering plant species were allowed to reinvade.

Grasses do not form a stable plant community (Egler, 1975) and selective herbicide treatments at regular intervals will likely be needed to maintain grass range or pasture. Such treatments often involve broadcast applications.

Standards C and D clearing practices on stable ground can only be justified when agricultural needs are identified. When these requirements are not clearly established, clearing standards A and B would better serve wildlife shelter and forage needs.

Although seeding to grass is a worthwhile biological control method, undergrazing on grassed areas may result in an abundance of long dead grasses on the T/L R.O.W. in the spring, posing a fire hazard to forested areas.

Manual controls can improve wildlife habitat, especially in conjuction with herbicidal spot treatments on cut stumps of deciduous trees prone to suckering.

In practice manual controls are often overdone by workers who cannot distinguish between desirable and undesirable species.

Mechanical mowing by hydro-axe often removes vegetation indiscriminately, thereby destroying wildlife shelter and forage. Shade intolerant coniferous tree species may be released (Table 2), while conifers cut above the lowest branches will produce multiple leaders. Disturbing unstable terrain with the hydro-axe tires will permit colonization by undesirable vegetation.

Lasting control of deciduous trees prone to vegetative regeneration (Table 2) is not achieved unless mowing is done in conjunction with herbicidal spot treatments.

Although the hydro-axe is a valuable tool for short-term vegetation maintenance it is not a good management tool by itself. Wildlife concerns are not served best where it is employed without other selective techniques.

Biological controls, by encouraging desirable vegetation on the powerline right-of-way, best serves the needs of man, wildlife, and the environment. Over a long term it is the most economical, sensible, and natural method to manage right-of-way vegetation, especially when indigenous desirable plant species are manipulated to dominate the right-of-way environment. Where this method is employed, rights-of-way support an incredible diversity of flora and fauna benefiting man and wildlife alike.

Table 2 indicates the response of tall growing trees to the physical changes caused by controlling vegetation. Knowledge of regenerative capacity, shade tolerance, and seeding capabilities can be used as criteria for the selection of site specific vegetation management.

It is evident that all control methods are needed to establish a rational vegetation management plan which will achieve maximum biological control.

Chemical controls are an essential tool to augment biological control. The use of herbicides to establish better wildlife habitat is not a new concept. In "The Role of Herbicides in Wildlife Management" (Leonard and Cain, 19) it is reported that conservation agencies recognize herbicides as valuable management tools to improve wildlife habitat.

Public controversy is usually triggered when indiscriminate broadcast applications cause massive "brown-outs". Such broadcast applications are seldom required when manipulating right-of-way vegetation to attain maximum biological control. Even foliar and pellet spot applications with hormonal type herbicides, such as 2,4-D and picloram, often cause unnecessary overkills of desirable plant species.

Slashing of coniferous and deciduous trees, followed by stump treatment of the deciduous trees prone to suckering, is a reasonable control method which will retain more wildlife forage and minimize public furor.

Alternatively stem injection, banding, lacing, root collar, or soil applied grid patterns are reasonable selective chemical treatments which will minimize environmental impacts and retain more wildlife forage. These alternative techniques will undoubtedly become more popular when additional registered uses for the herbicides glyphosate and tebuthiuron are approved. The registration of hexazinone for right-of-way use and in particular the Velpar gridball formulation would further augment the meager selection of chemical tools available at present.

Easy access to rights-of-way has proven to be detrimental to the T/L R.O.W. environment. Four-wheel drive, all-terrain, and other recreational vehicles damage right-of-way vegetation, spread seeds of noxious and other undesirable plant species, and disturb unstable terrain causing erosion, while opening up niches for unwanted vegetation. These disturbances to vegetation and terrain adversely affect wildlife habitat as does the noise from such traffic.

Additionally, gates are often torn out and signs, insulators, and conductors are used for target practice. Such deplorable behaviour by "trigger happy road hunters" does not benefit wildlife and reflects negatively on the legitimate hunter and his recreation.

Vegetation managers should pay particular attention to these problems and jealously guard access to transmission line rights-of-way.

Conclusion

Multiple uses, compatible with transmission line engineering needs, are to be encouraged and benefit the user and the power company. The indicated multiple use for R.O.W., when agricultural needs are not clearly demonstrated, is wildlife habitat. This management strategy calls for biological control by establishing vegetation comprised of indigenous plant species compatible with engineering requirements. This strategy is most effective, aesthetically pleasing, and economical.

Chemical control is unavoidable to establish and maintain biological control. Broadcast chemical applications are often detrimental and should be replaced with site-specific spot applications which will minimize overkill. This strategy will decrease the use of chemicals as biological control progresses.

Vegetation management must replace vegetation maintenance. Maintenance is defined as the short-term control measures taken at lowest cost to solve an acute problem. Objectives of vegetation management for specific T/L R.O.W. must be established. When objectives

are decided, a vegetation management prescription must clearly describe the management techniques to be used.

All too often cost/benefit studies are undertaken to determine the most economical control method: physical or chemical. Such studies show a misconception of vegetation management. This myopia is a paranoic response to public controversy resulting in naive conclusions. The best control methods, which serve all interests including wildlife, are biological. In this biological control all other control techniques are judiciously used in integrated pest management.

Acknowledgements

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TABLE 1. WOODY PLANT SPECIES WHICH ARE OFTEN COMPATIBLE WITH T/L R.O.W. AND ARE KEY WINTER FORAGE PLANTS FOR BRITISH COLUMBIA UNGULATES*

Botanical Name	Common Name	Ungulate Importance Ranking								
		coast deer	mule deer	white tail deer	mtn goat	big horn sheep	Roos-evelt elk	Rocky Mtn elk	moose	caribou
Acer circinatum	vine maple	1	3	3	2	3	3	3	3	3
Acer glabrum	Douglas maple	2	1	2	1	2	2	1	2	3
Amelanchier alnifolia	Saskatoon berry	3	1	1	2	2	3	1	1	3
Arctostaphylos uva-ursi	bearberry	3	1	2	2	2	3	3	3	3
Artimisia frigida	pasture sage	3	1	2	3	1	3	2	3	3
Artimisia tridentata	big sagebrush	3	2	3	3	2	3	2	3	3
Berberis spp.	Oregon grapes	2	2	2	2	2	2	2	3	3
Betula glandulosa	scrub birch	3	3	3	3	3	3	2	1	2
Betula occidentalis	water birch	3	2	3	3	3	3	2	1	3
Ceanothus sanguineus	redstem ceanothus	1	1	2	2	3	3	2	2	3
Ceanothus velutinus	snow brush	3	1	2	2	3	3	2	2	3
Chrysothamnus nauseosus	stinking rabbitbrush	3	2	3	3	2	3	2	3	3
Cornus stolonifera	red-osier dogwood	2	2	2	1	3	1	2	1	2
Corylus spp.	filberts	3	2	2	3	3	3	3	2	3
Gaultheria shallon	salal	1	3	3	3	3	1	3	3	3
Holodiscus discolor	ocean spray	2	2	3	3	3	3	3	3	3
Juniperus communis	common juniper	3	2	3	2	3	3	2	3	3
Lonicera involucrata	black twinberry	3	3	3	2	3	2	3	2	3
Menziesia ferruginea	false azalea	2	3	3	3	3	2	3	3	3
Oplopanax horridus	devil's club	3	3	3	3	3	1	2	3	3
Pachistima myrsinites	false box	3	1	2	1	3	3	2	1	1
Penstemon spp.	penstemons	3	1	2	2	3	3	3	3	3
Philadelphus lewisii	mock orange	3	2	2	3	3	3	2	3	3
Physocarpus spp.	ninebarks	2	3	3	3	3	2	3	3	3
Prunus spp.	wild cherries	2	2	2	3	3	3	1	2	3
Purshia tridentata	antelope bush	3	2	2	3	3	3	1	2	3
Rhamnus purshiana	cascara	1	3	3	3	3	2	2	3	3
Rhus glabra	sumac	3	1	2	3	2	3	3	3	3
Ribes spp.	currants	2	3	3	3	3	2	3	3	3
Rosa spp.	roses	2	2	2	3	3	2	2	3	3
Rubus pedatus	trailing rubus	2	3	2	3	3	2	3	3	2
Rubus spectabilis	salmonberry	2	3	3	3	3	3	3	3	3
Rubus ursinus	trailing blackberry	1	3	3	3	3	2	3	3	3
Salix spp.**	willows	2	2	2	1	3	2	2	1	2
Sambucus spp.	elderberries	2	3	3	3	3	1	2	3	3
Sorbus spp.	mountain ashes	3	3	3	3	3	2	3	1	2
Symphoricarpos spp.	snowberries	3	2	3	3	3	3	2	3	3
Vaccinium spp.	huckleberries/ blueberries	1	3	3	3	3	2	2	2	3
Viburnum edule	squashberry	3	3	3	2	3	2	3	2	3

RANKING CODE: 1 - high importance
2 - moderate importance
3 - low importance

*Adapted from: Key Winter Forage Plants for B. C. Ungulates, 3rd Draft, (Blower, 1982).

** A wide range in palatability exists within the willows, varying from very high to low. "Upland willows", as a general group (e.g. Bebb's willow, Scouler's willow), are mainly highly palatable.

Vascular Plant Names Reference: Common and Botanical Names of Weeds in Canada, (Anon., 1975).
Trees, Shrubs and Flowers to Know in British Columbia, (Lyons, 1974).

TABLE 2. REGENERATION CAPACITY AND SHADE TOLERANCE OF TREES IN BRITISH COLUMBIA

Botanical Name	Common Name	Vegetative Regeneration (stump and/or roots)	Shade Tolerance	Normal Mature Height (metres)	Remarks
Abies amabilis	amabilis fir		tolerant	24-38	
Abies grandis	grand fir		tolerant	30-38	poor seed producer
Abies lasiocarpa	alpine fir		very tolerant	20-30	
Acer macrophyllum	bigleaf maple	yes	tolerant	15-21	
Alnus rubra	red alder	yes	intolerant	to 24	
Alnus rugosa	speckled alder	yes	intolerant	to 9	
Arbutus menziesii	arbutus		very intolerant	10-12	
Betula neoalaskana	Alaska birch	yes	intolerant	6-12	
Betula papyrifera	white birch	yes	intolerant	to 24	
Chamaecyparis nootkatensis	yellow cypress			18-24	may take 200 years to mature
Cornus nuttali	western flowering dogwood (Pacific white dogwood)	yes	tolerant	to 10	
Juniperus scopulorum	Rocky Mountain juniper		intolerant	up to 9	
Larix laricina	tamarack		very intolerant	9-22	
Larix lyallii	alpine larch		very intolerant	9-12	
Larix occidentalis	western larch		very intolerant	30-55	
Picea engelmannii	Engelmann spruce		tolerant	30-36	
Picea glauca	white spruce		tolerant	24-30	
Picea mariana	black spruce	layering	tolerant	9-15	
Picea sitchensis	Sitka spruce		very tolerant	38-53	
Pinus albicaulis	whitebark pine		intolerant	to 12	
Pinus contorta var. contorta	shore pine		intolerant	5-15	
Pinus contorta var. latifolia	lodgepole pine		intolerant	15-30	
Pinus flexilis	limber pine		intermediate tolerance	8-12	
Pinus monticola	western white pine		intolerant	27-34	
Pinus ponderosa	ponderosa pine		intolerant	23-30	
Populus balsamifera	balsam poplar	yes	intolerant	18-24	
Populus tremuloides	trembling aspen	yes	intolerant	12-18	
Populus trichocarpa	black cottonwood	yes	intolerant	24-38	
Prunus emarginata	bitter cherry		intolerant	12-15	
Prunus pennsylvanica	pin cherry		intolerant	12-15	
Pseudotsuga menziesii	Douglas fir		very intolerant	45-60	
Salix spp.	willows	yes	intolerant		
Taxus brevifolia	western yew		tolerant	5-8	
Thuja plicata	western red cedar	yes	tolerant	45-60	
Tsuga heterophylla	western hemlock		very tolerant	36-50	
Tsuga mertensiana			tolerant	8-15	

Compiled from: Native Trees of Canada (Hosie, 1975).
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